**Citation:**

Corrada MM, Kawas CH, Mozaffar F, Paganini-Hill A. Association of body mass index and weight change with all-cause mortality in the elderly.*Am J Epidemiol.* 2006 May 15;163(10):938-49.

**PubMed ID:** 16641311

**Study Design:**

Population-based Cohort Study

**Class:**

B - Click here for explanation of classification scheme.

**Research Design and Implementation Rating:**

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

**Research Purpose:**

The purpose of this study was to explore the associations between BMI at study entry, BMI at age 21 years, and weight change and all-cause mortality in the elderly.

**Inclusion Criteria:**

All residents of the Leisure World Laguna Hills retirement community who in 1981, 1982, 1983, and 1985 returned mailed health questionnaires.

**Exclusion Criteria:**

No exclusion criteria reported.

**Description of Study Protocol:**

**Recruitment** All residents who owned homes in Leisure World Laguna Hills, a retirement community in California as of June 1, 1981, along with any residents who moved into the community after this date in 1982, 1983 and 1985.

**Design:** Population-based cohort study

**Blinding used (if applicable):** not applicable

**Intervention (if applicable):** not applicable

**Statistical Analysis**

Cox regression to estimate the relative risk of all-cause mortality associated with BMI at study entry, BMI at age 21 years, and weight change from age 21 to study entry.

**Data Collection Summary:**

**Timing of Measurements**

Surveys were mailed to residents in 1981, and also to those who moved in to the retirement community in 1982, 1983, and 1985.

**Dependent Variables**

- All-cause mortality confirmed by periodic resurveys, reviews of local hospital discharge records, and determination of vital status through searches of national and commercial death indexes and ascertainment of death certificates.

**Independent Variables**

- Self reported weight and height at age 21. Corresponding BMI calculated and categorized according to federal guidelines: underweight (< 18.5), normal weight (18.5-24.9), overweight (25-29.9), and obese (≥ 30).

- Weight change calculated as percent change in weight from age 21 to study entry [100 x (wt at entry - wt at age 21)/wt at age 21] classified into 4 categories: >5 % loss, ≤ 5% change (stable), >5-15% gain, and >15% gain.

**Control Variables**

- Physical activity
- Medical history
- Age at study entry
- Smoking
- Gender

**Description of Actual Data Sample:**

**Initial N**: 13,978

**Attrition (final N):** 13,451 (527 deleted due to missing data)

**Age**: study entry mean age = 73 years (range = 44-101 years)

**Ethnicity**: primarily Caucasian

**Other relevant demographics**: educated, upper middle class, and 64% female

**Anthropometrics** Mean BMI at age 21 years = 21.3 (range= 14.1 - 44.0); mean BMI at study entry = 23.5 (range = 12.4 - 54.1)

**Location** California

**Summary of Results:**

**Key Findings**

BMI at Study Entry

- The relation between BMI at study entry and all-cause mortality, adjusted for age at entry, gender and smoking, showed a reverse J-shaped relation. Compared to normal weight participants, underweight participants had highest mortality at RR = 1.51, with overweight participants at RR = 1.01 and obese participants at RR =1.25. When same analysis was done with the first 5 years of follow-up excluded, the curve changed to a U-shape. Adjustment for physical activity and medical history attenuated the RR for obese persons, making the association once again reverse J-shaped. (see table below)

BMI at Age 21 Years

- The relation between BMI at age 21 years and all cause mortality, adjusted for age at entry, gender and smoking was significantly increased among participants who were overweight/obese at age 21. Compared to normal weight at age 21, overweight/obese participants at 21 years of age had RR = 1.17, whereas, underweight participants at age 21 had RR= 1.05. Adjustments for physical activity and medical history resulted in similar risk estimates. Excluding the first 5 years of follow-up had little effect on the association between BMI at age 21 and all-cause mortality.

Weight Change

- All-cause mortality and weight at age 21 years by weight-change category, adjusted for age at entry, gender and smoking, showed significant increase in mortality for those who lost weight regardless of their weight at age 21 (underweight RR= 1.93, normal weight RR= 1.28, and overweight/obese RR= 1.26). Mortality was also significantly increased among persons who were underweight at age 21 and whose weight remained stable (RR= 1.48). The same was true for those who were overweight/obese at age 21 and gained more than 15.5% of their body weight (RR= 1.32). Adjusting for physical activity and medical history, the RR were generally similar in magnitude, but statistical significance of some risks changed. Most notably, there was a significantly lower mortality with weight gain among persons who were underweight or normal weight at age 21. (See table below)

Stratification by Smoking Status

- The association between BMI at study entry and all-cause mortality varied among the different smoking categories: Never Smokers underweight RR= 1.26 (95 percent CI: 1.12, 1.43) and Never Smokers obese RR= 1.35 (95 percent CI: 1.17, 1.57). For Past Smokers the highest mortality was seen among underweight participants RR= 1.81 (95 percent CI: 1.54, 2.14) although Past Smokers obese RR=1.19 (95 percent CI: 1.03, 1.38). For underweight Current Smokers RR= 1.99 (95 percent CI: 1.61, 2.46) while overweight or obese Current Smokers did not differ from persons of normal weight. Excluding the first 5 years of follow-up slightly changed the curves for the three smoking categories as the RR among underweight participants in all smoking categories, especially Past Smokers were attenuated, and conversely the RR among

obese Past Smokers was slightly increased.

Stratification by Age

- The association between BMI at study entry and all-cause mortality for four designated age categories showed a reverse J shape. While obese participants aged less than 70 years or aged 70-74 years had increased mortality compared to normal-weight, the mortality of obese participants aged 75-79 years (RR= 1.12, 95 percent CI: 0.94, 1.58) was not significantly different from that of normal-weight participants. Conversely, overweight participants aged ≥ 80 years had significantly lower mortality than normal-weight participants (RR= 0.89, 95 percent CI: 0.81, 0.98).

**Relative Risk of all-cause mortality by body mass index (BMI) category at study entry**

| BMI Category | Median BMI | # participants | # deaths | Model 1* | | Model 2** | | Model 3*** | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | RR§ | 95% CI§ | RR | 95% CI | RR | 95% CI |
| ***All participants*** | | | | | | | | | |
| Underweight BMI <18.5 | 17.6 | 556 | 518 | 1.51 | 1.38,1.65 | 1.50 | 1.37, 1.64 | 1.53 | 1.40, 1.67 |
| Normal weight BMI 18.5-24.9 | 22.4 | 9,021 | 7,501 | 1.00 | reference | 1.00 | reference | 1.00 | reference |
| Overweight BMI 25-29.9 | 26.5 | 3,376 | 2,784 | 1.01 | 0.97, 1.06 | 0.99 | 0.95, 1.03 | 0.97 | 0.93, 1.01 |
| Obese BMI ≥ 30 | 31.6 | 498 | 400 | 1.25 | 1.13, 1.38 | 1.18 | 1.07, 1.31 | 1.12 | 1.01, 1.24 |
| ***Excluding the 1st 5 years of follow-up*** | | | | | | | | | |
| Underweight BMI <18.5 | 17.8 | 390 | 352 | 1.39 | 1.24, 1.54 | 1.38 | 1.24, 1.54 | 1.42 | 1.27, 1.58 |
| Normal weight BMI 18.5-24.9 | 22.4 | 7,611 | 6,091 | 1.00 | reference | 1.00 | reference | 1.00 | reference |
| Overweight BMI 25-29.9 | 26.5 | 2,937 | 2,345 | 1.04 | 0.99, 1.09 | 1.02 | 0.98. 1.08 | 1.00 | 0.95, 1.05 |
| Obese BMI ≥ 30 | 31.6 | 437 | 339 | 1.27 | 1.14, 1.42 | 1.22 | 1.10, 1.37 | 1.16 | 1.04, 1.29 |

* Results were adjusted for age at entry, gender, and smoking. ** Results were adjusted for age at entry, gender, smoking and "active activities (7 categories). ***Results were adjusted for age at entry, gender, smoking, "active" activities (7 categories, and history of HTM, angina, myocardial infarction, stroke, diabetes, arthritis, and cancer. **§ RR, relative risk, CI,confidence interval.**

**Relative risk of all-cause mortality by category of weight change from age 21 yrs to study entry**

| Weight change | Wt change % | | Wt change pounds | | # participants | # deaths | Model #1* | | Model #2** | | Model #3*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | median | range | median | range | | | RR§ | 95% CI§ | RR | 95% CI | RR | 95% CI |
| ***Underweight BMI < 18 at age 21 years*** | | | | | | | | | | | | |
| Weight loss >5% | -10 | -32.7 to 5.1 | -10 | -34 to -5 | 37 | 34 | 1.93 | 1.37, 2.70 | 1.94 | 1.38, 2.72 | 1.87 | 1.33, 2.63 |
| Stable weight (within 5%) | 0 | -5.0 to 5.0 | 0 | -6 to 6 | 147 | 137 | 1.48 | 1.24, 1.76 | 1.43 | 1.20, 1.70 | 1.45 | 1.22, 1.73 |
| Weight gain 5.1-15% | 10.6 | 5.1 to 15.0 | 11 | 5 to 20 | 260 | 215 | 1.12 | 0.97, 1.28 | 1.10 | 0.96, 1.27 | 1.09 | 0.95, 1.26 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight gain > 15% | 30 | 15.1 to 104.5 | 31 | 13 to 100 | 964 | 768 | 0.97 | 0.90, 1.06 | 0.94 | 0.87, 1.02 | 0.90 | 0.83, 0.98 |
| ***Normal weight BMI 18.5-24.9 at 21 years of age*** | | | | | | | | | | | | |
| Weight loss >5% | -9.6 | 33.3 to -5.0 | -13 | -55 to -5 | 1,293 | 1,169 | 1.28 | 1.19, 1.37 | 1.27 | 1.18, 1.36 | 1.26 | 1.17, 1.35 |
| Stable weight (within 5%) | 0.8 | -5.0 to 5.0 | 1 | -9 to 10 | 2,725 | 2,275 | 1.00 | reference | 1.00 | reference | 1.00 | reference |
| Weight gain 5.1-15% | 9.7 | 5.0 to 15.0 | 12 | 5 to 25 | 3,324 | 2,728 | 0.96 | 0.91, 1.01 | 0.95 | 0.90, 1.00 | 0.93 | 0.88, 0.99 |
| Weight gain > 15% | 23 | 15.0 to 141.4 | 30 | 15 to 164 | 3,672 | 2,966 | 0.97 | 0.92, 1.02 | 0.94 | 0.88, 0.99 | 0.90 | 0.85, 0.95 |
| ***Overweight/obese BMI ≥ 25 at age 21 years*** | | | | | | | | | | | | |
| Weight loss >5% | -12.5 | -53.6 to -5.1 | -20 | -133 to -7 | 441 | 403 | 1.26 | 1.13, 1.40 | 1.25 | 1.12, 1.39 | 1.23 | 1.10, 1.37 |
| Stable weight (within 5%) | 0 | -5.0 to 5.0 | 0 | -10 to 10 | 273 | 241 | 1.05 | 0.92, 1.20 | 1.02 | 0.89, 1.16 | 1.00 | 0.88, 1.14 |
| Weight gain 5.1-15% | 8.8 | 5.1 to 15.0 | 15 | 7 to 30 | 201 | 173 | 1.09 | 0.93, 1.27 | 1.06 | 0.91, 1.24 | 1.00 | 0.86, 1.17 |
| Weight gain > 15% | 19.8 | 15.2 to 84.4 | 30.5 | 20 to 135 | 114 | 94 | 1.32 | 1.08, 1.63 | 1.25 | 1.02, 1.54 | 1.15 | 0.93, 1.41 |

* Results were adjusted for age at entry, gender, and smoking. ** Results were adjusted for age at entry, gender, smoking and "active activities (7 categories). ***Results were adjusted for age at entry, gender, smoking, "active" activities (7 categories, and history of HTM, angina, myocardial infarction, stroke, diabetes, arthritis, and cancer. **§ RR, relative risk, CI,confidence interval.**

**Author Conclusion:**

This study suggests that all-cause mortality in older adults is increased among persons who were overweight or obese at age 21 years. Both weight loss between age 21 and later life (regardless of weight at age 21) and being underweight at age 21 but not gaining weight later in life were associated with increased mortality. Conversely, being of normal weight at age 21 and gaining weight by late adulthood was associated with decreased all-cause mortality.

***Reviewer Comments:***

*23 year follow-up. Authors note the following limitations:*

- *Unable to determine when the weight change occurred or to distinguish between gradual weight change and rapid weight change, fluctuating weight and relatively stable weight, and intentional weight change and unintentional weight change*
- *Use of self-reported data on height and weight*
- *Recall of weight at 21 years*

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***Research Design and Implementation Criteria Checklist: Primary Research***

**Relevance Questions**

| | | |
|---|---|---|
| 1. | Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies) | N/A |
| 2. | Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about? | Yes |
| 3. | Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice? | Yes |
| 4. | Is the intervention or procedure feasible? (NA for some epidemiological studies) | N/A |

**Validity Questions**

| | | |
|---|---|---|
| **1.** | **Was the research question clearly stated?** | Yes |
| 1.1. | Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified? | Yes |
| 1.2. | Was (were) the outcome(s) [dependent variable(s)] clearly indicated? | Yes |
| 1.3. | Were the target population and setting specified? | Yes |
| **2.** | **Was the selection of study subjects/patients free from bias?** | Yes |
| 2.1. | Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study? | Yes |
| 2.2. | Were criteria applied equally to all study groups? | Yes |
| 2.3. | Were health, demographics, and other characteristics of subjects described? | Yes |
| 2.4. | Were the subjects/patients a representative sample of the relevant population? | Yes |
| **3.** | **Were study groups comparable?** | Yes |
| 3.1. | Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT) | Yes |
| 3.2. | Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline? | Yes |
| 3.3. | Were concurrent controls used? (Concurrent preferred over historical controls.) | N/A |
| 3.4. | If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis? | Yes |
| 3.5. | If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.) | N/A |
| 3.6. | If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")? | N/A |
| **4.** | **Was method of handling withdrawals described?** | Yes |
| 4.1. | Were follow-up methods described and the same for all groups? | Yes |
| 4.2. | Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.) | Yes |
| 4.3. | Were all enrolled subjects/patients (in the original sample) accounted for? | Yes |

| | | |
|---|---|---|
| 4.4. | Were reasons for withdrawals similar across groups? | N/A |
| 4.5. | If diagnostic test, was decision to perform reference test not dependent on results of test under study? | N/A |
| **5.** | **Was blinding used to prevent introduction of bias?** | ??? |
| 5.1. | In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate? | N/A |
| 5.2. | Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.) | ??? |
| 5.3. | In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded? | ??? |
| 5.4. | In case control study, was case definition explicit and case ascertainment not influenced by exposure status? | N/A |
| 5.5. | In diagnostic study, were test results blinded to patient history and other test results? | N/A |
| **6.** | **Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?** | Yes |
| 6.1. | In RCT or other intervention trial, were protocols described for all regimens studied? | N/A |
| 6.2. | In observational study, were interventions, study settings, and clinicians/provider described? | Yes |
| 6.3. | Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect? | Yes |
| 6.4. | Was the amount of exposure and, if relevant, subject/patient compliance measured? | N/A |
| 6.5. | Were co-interventions (e.g., ancillary treatments, other therapies) described? | N/A |
| 6.6. | Were extra or unplanned treatments described? | N/A |
| 6.7. | Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups? | N/A |
| 6.8. | In diagnostic study, were details of test administration and replication sufficient? | N/A |
| **7.** | **Were outcomes clearly defined and the measurements valid and reliable?** | No |
| 7.1. | Were primary and secondary endpoints described and relevant to the question? | Yes |
| 7.2. | Were nutrition measures appropriate to question and outcomes of concern? | Yes |
| 7.3. | Was the period of follow-up long enough for important outcome(s) to occur? | Yes |
| 7.4. | Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures? | No |
| 7.5. | Was the measurement of effect at an appropriate level of precision? | ??? |
| 7.6. | Were other factors accounted for (measured) that could affect outcomes? | Yes |
| 7.7. | Were the measurements conducted consistently across groups? | ??? |
| **8.** | **Was the statistical analysis appropriate for the study design and type of outcome indicators?** | Yes |
| 8.1. | Were statistical analyses adequately described and the results reported appropriately? | Yes |
| 8.2. | Were correct statistical tests used and assumptions of test not violated? | Yes |
| 8.3. | Were statistics reported with levels of significance and/or confidence intervals? | Yes |
| 8.4. | Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)? | N/A |

| | | | |
|---|---|---|---|
| | 8.5. | Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)? | Yes |
| | 8.6. | Was clinical significance as well as statistical significance reported? | Yes |
| | 8.7. | If negative findings, was a power calculation reported to address type 2 error? | N/A |
| **9.** | **Are conclusions supported by results with biases and limitations taken into consideration?** | | Yes |
| | 9.1. | Is there a discussion of findings? | Yes |
| | 9.2. | Are biases and study limitations identified and discussed? | Yes |
| **10.** | **Is bias due to study's funding or sponsorship unlikely?** | | Yes |
| | 10.1. | Were sources of funding and investigators' affiliations described? | Yes |
| | 10.2. | Was the study free from apparent conflict of interest? | Yes |